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ABSTRACT

These training materials are designed to help vocational education teachers introduce students to the utilization and installation of mini- and microcomputers in residential and small business buildings. It consists of two chapters. Chapter 1 contains general materials, designed to promote awareness, and chapter 2 contains materials which are specific and designed for teachers of electricity, heating, and air conditioning. Topics discussed in chapter 1 are uses of the computer in the home, physical characteristics of the computerized house, characteristics of the computer, installation, practical implications for living in the home of the future, and selecting system components. Chapter 2 contains specific materials designed to help teachers of electricity and heating and air conditioning develop lesson plans which introduce students to the concept of computerized homes and buildings. It is divided into four sections. Section 1 reviews installation procedures for plans, sensor placement, and the function of the computer in two types of heating/cooling systems. Section 2 covers hardware considerations for input and output devices. Detailed discussion of sensors comprises section 3. Section 4 contains sample problem worksheets for students in electricity and heating and air conditioning classes. (MN)

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FINAL REPORT

MINI-COMPUTERS AND THE BUILDING TRADES
A GUIDE FOR TEACHERS OF VOCATIONAL EDUCATION

(Contract Number 85-9828)

133

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ABSTRACT

PA85-9828: Mini Computers and the Building Trades: A Guide for Teachers of Vocational Education

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The purpose of this project was to develop curriculum materials that may be utilized in the building trades explaining means by which mini- and micro-computers may be utilized in homebuilding and construction of small business buildings.

Objectives

The objective was to develop resource materials for vocational educators in the building trades which will assist in teaching students:

1. How to choose the type of mini-computer suitable for particular building and functions to be performed.
2. How to install computer systems to operate effectively over a range of demands.
3. To identify potential difficulties in computers, both in hardware and software, so that computers will operate as trouble free as possible.
4. To identify potential uses of the computer and to promote awareness of the computer's potential.

Outcomes

Materials were developed to provide vocational education teachers with a means of introducing students to the utilization and installation of mini- and micro-computers in residential and small business buildings. Material developed included:

1. General materials designed to promote awareness of the utilization of mini- and micro-computers in the building trades.
2. Specific materials designed for teachers of electricity, heating and air conditioning.
3. Examples of worksheets to be used with students in class.

Evidence

The materials should be useful for teachers of electricity, heating and air conditioning.

Publications

Final Report

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INTRODUCTION

Just five years ago (1975), there were no home computers and apparently there was no market for them. Since then dramatic developments in mini- and microcomputer technology have resulted in marked growth within the data processing industry. In 1976, the home computer was first introduced and initial sales were primarily to hobbyists. This trend continued through 1977, with a modest increase in sales. However, in 1978, there was a tremendous increase in the number of home computers built and sold to people other than hobbyists. Perhaps the greatest reason for this increase has been the discovery that inexpensive mini- and microcomputers can be used to perform various functions within the home and small business buildings.

PREFACE

The basic purpose of these training materials is to provide vocational education teachers with a means of introducing students to the utilization and installation of mini- and microcomputers in residential and small business buildings. The goal is to awaken future practitioners both to the potential of the computer in general and to its design and functional implications in the construction of automated homes and buildings.

The great number of recent articles in popular magazines exploring the potential uses of home computers attests to the timeliness of the concept. One automated house has already been built outside of Phoenix, Arizona, and others are under construction. The goal of the builders of the "House of the Future" was to make microcomputers an unobstrusive, but integral part of family life.[1] To do this they have used a five-microcomputer network that

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[1]Larry Waller, "Microcomputers to Run-Test House," Electronics, July 19, 1979, pp. 92-93.

controls and manages all of the home's electrical, environmental, and security requirements. While construction of this prototype was expensive, competition within this growing industry and improved technology are expected to bring down costs rapidly in the next decade. Many people feel that the computerized house will be a reality for many American families by 1990.

MATERIALS DEVELOPMENT

These materials were developed by West Chester State College, in cooperation with the Homebuilders Association of Chester County, an affiliate of The National Association of Home Builders (NAHB), and vocational educators from local vocational/technical schools. An Advisory Committee was established to provide the staff with advice and general guidance regarding the direction and content of this report. The Committee included staff from West Chester State College involved with the project, builders, architects, engineers, marketing representatives and potential consumers.

THE STAFF

These materials were prepared through the cooperative efforts of many people. The Project Director, Dr. Ernest Peters, Director of Adult and Continuing Education at West Chester State College, was responsible for the overall administration of the project and wrote the introductory portions and the section on potential uses of the computer. Mr. Wesley Fasnacht, Associate Professor of Computer Science, West Chester State College, assisted with administration and was responsible for the sections dealing with the computer itself. Mr. Donald Asplen, Research Associate and Computer Science major at West Chester State College, contributed in all areas, but his primary responsibility was the section on sensors. Finally, Mr. Stephen Crane, President of the Homebuilders Association of Chester and Delaware Counties and president of his own

construction firm; Mr. Robert Robinson, teacher at Delaware County Area Vocational Technical School; and Mr. Joseph Burinsky, teacher at Western Montgomery County Area Vocational Technical School contributed to the entire set of materials, but had primary responsibility for the practical applications guides.

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Mr. Ned Hoffner, Builder

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ACKNOWLEDGEMENTS

The development of these materials was made possible through a contract with the Research Coordinating Unit for Vocational Education, Bureau of Vocational Education, Pennsylvania Department of Education, Harrisburg, Pennsylvania. West Chester State College contributed secretarial assistance as well as office space for staff members.

BACKGROUND AND NEED

The American public has always been interested in finding faster and more efficient ways to perform tasks, particularly in the home. Modern conveniences have been designed to make life simpler and easier. To paraphrase one builder with whom we spoke, Americans have always been comfort oriented. Certainly their sophisticated technology reflects this.

With the development of mini- and microcomputers, the possibility now exists to completely automate the home. This would mean added convenience, freedom from boring chores, greater assurance of timely and adequate attendance to all essential activities, a safer home, and, most importantly today, conservation of energy.

Many tasks involved in managing a home or building are currently performed by manual or mechanical means. When performed manually, these jobs are often time-consuming and encumbering; often they are done haphazardly. For instance, opening and closing drapes to regulate the amount of sunlight in a room is a task which can be performed manually. However, it requires that a well-organized person be present to perform the required task at the appropriate time. With computer home management these constraints no longer exist.

Mechanical devices are also now used to perform household tasks automatically. For instance, electrical security systems can now automatically call the police and set off an alarm when doors or windows are disturbed. These devices are decision-makers; however, they are still limited in terms of what can be programmed into the decision-making process. The computer, on the other hand, is a decision-maker which can be programmed to perform many more subtle and complex tasks. For instance, the computer can store pertinent data over time to develop a family profile, and on the basis of that, can make decisions about controlling all facets of the family's environment.

METHODS USED

The staff examined the literature to determine the state of the art in the use of computers in facility management and its other potential uses in the home and in small businesses. Staff members from West Chester State met with staff members of the National Association of Home Builders in Washington and

with home builders from the Homebuilders Association of Chester and Delaware Counties to determine potential uses of the computer in building construction, and areas of concern to owners of homes and small businesses relating to convenience, security, and economics. Potential homeowners also provided input in these areas. Manufacturers were asked to send specifications on equipment and software currently available.

ORGANIZATION OF MATERIALS

The materials are divided into two chapters. Chapter One contains general materials designed to promote awareness. Chapter Two contains materials which are specific and designed for teachers of electricity, heating, and air conditioning.

POTENTIAL USES OF THE COMPUTER IN THE HOME

In an effort to determine convenience, security and economic concerns surrounding the use of microcomputers in the home, a sample of homebuilders and potential consumers were interviewed. We asked them to "blue-sky" it and think of as many potential uses for the computer as possible. This was also accomplished with two staff members at the National Association of Home Builders in Washington, D.C., and with a staff member at the NAHB Research Foundation.

The discussion was not limited to facility management. Many of their suggestions were thought-provoking; some were "far out", but most could easily be implemented today. The respondents generally predicted the computer's role in three major areas: facility management, home information processing, and community information processing. The following are uses described both by those associated with the building trades and by potential consumers.

Facility Management

1. Environmental Control. Heating, cooling, water quality control, and electric and gas utilization could be automatically regulated for maximum efficiency and low cost. Other suggestions in this category included control of air flow and ionization (air filtration). Blinds and shades could be controlled to allow sun only when appropriate. One consultant suggested the computer could help administer medication to the sick confined to sleeping pods in the house. This idea seemed more futuristic than most.
2. Security Control. Computers could insure that doors be locked except upon voice command; lights could be turned on and off automatically at specified times, whether or not the house was occupied; in case of fire or theft, the computer could deliver a pre-recorded message to the fire or police department.
3. Disaster Control. Computer-directed fire, smoke and water alert systems could allow timely reaction to disaster.
4. Lawn and Greenhouse Control. Sprinklers could be preset to water when the moisture content of the ground fell below a desirable point. Maintaining proper amounts of nutrients and moisture in greenhouses could also be made automatic.

Home Information Processing

1. Personal Data. A name and address file of friends and relatives; information about the family such as birthdays, anniversaries, children's names and ages; information about the family budget, charge accounts, insurance policies and investments could be always at hand. A homemaker could rely on the computer to maintain a food inventory, prepare shopping lists, file favorite recipes and plan

meals. Information regarding the life expectancy of appliances and their maintenance could be stored.

2. Message Board. The computer's TV monitor could provide a convenient message center to remind family members of appointments, birthdays and other important events.
3. Education. A computer could assist with instruction in virtually all areas of learning.
4. Entertainment. A wide variety of games, from tic-tac-toe to chess, could be played with the computer.
5. Health. Information regarding poison control, emergency first-aid treatments and emergency data of all types could be stored. The computer could also regularly monitor the blood pressure, body temperature, etc. of family members.

Community Information Processing

1. The microcomputer could provide access to several kinds of news information:
    a. UPI general wire service
    b. Real estate listings, including specifications of houses for sale
    c. Stock market information, monitored regularly, with stocks bought and sold via the computer
    d. Sample poll information
    e. Restaurant and entertainment listings
    f. Consumer and travel information
2. Shopping for sales on groceries, as well as soft and hard goods, could be done most economically by computer.
3. Miscellaneous consumer aids the computer would help provide might include:
    a. Electronic mail delivery

b. Automatic library searches

c. Health monitoring of patients who would not have to leave their homes to be examined by medical personnel

Respondents indicated two overriding consumer concerns regarding home computerization: cost effectiveness and savings in terms of time and convenience. (With regard to the latter, most felt that consumers would see facility management as the most important capability of microcomputers.) A large number felt that as long as it was economically feasible, people would computerize the home. Several builders hedged on this, however, indicating that many consumers would not purchase a computer if it did not begin to pay for itself within a reasonable time period. They also indicated that the homeowner would not purchase it if it were too complex.

Opinions differed on whether the consumer would purchase a computer for home information processing. Most felt that if there were a business application available, the consumer would be likely to pay for this capability because of the potential for improving his/her profit picture. However, they felt that unless much of what could be accomplished with home information processing was done with the existing computer for facility management, the service would not seem worth it.

Many respondents saw the virtues of a community information processing system but expressed the fear that the government might use it to gain access to too much personal data, particularly financial information. The general feeling was that only a few potential consumers would be interested in tapping into the services currently available, such as UPI news, stock market quotations, etc. However, with the proliferation of computers allowing instant communication, this might someday be a convenience that consumers would want.

PHYSICAL CHARACTERISTICS OF THE BUILDING

Design Environment

Design would be a primary consideration in the construction of a computerized house. The uniqueness of this type of processing unit would seem at first to impose constraints in drafting plans for a house or building. But advanced construction practices now provide new opportunities in design.

The designer of the computerized home must first realize that future houses will contain a great deal of insulation, thereby limiting the total amount of heating or cooling required of the computer. In fact, in a typical suburban setting in the northern half of the United States fans alone would probably be sufficient to cool the computer-managed home. Because of the "self-contained" nature of the environment within the computerized home, the designer would focus on the relationship between the interior and the exterior. The greatest design concerns would probably be conditions such as outside air temperature, wind direction and speed, humidity, temperature of the ground below frostline (for some applications), as well as the temperature of deep bodies of water nearby (wells, ponds, swimming pools). Since the house could become an independent air system, ventilation would have to be carefully considered since combustion of gas, oil or wood could create poor air quality.

In order to conserve energy and upgrade room environment, individual rooms of a house may need to be separately controlled. Doors to rooms may have to be made airtight, and the once standard design of an airtight entrance vestibule with a well-defined central hall could make a comeback.

Each room's function would determine its controls. A bedroom might be heated at night but left unheated during the day, except when a sensor perceived the presence of a person. A business might vent an area only when a sensor detected the presence of fumes or too much dust. While many of the output

devices for these applications are now available (including means to control temperature, humidity, etc.), many are not; so, a limited selection of materials might dictate certain features of design.

Building energy management via computer is almost a field of its own. Areas of concern include: the ability to direct energy or heat only to rooms in use, to heat water, to divert heat from sources such as large machines (washers, dryers, etc.) and to run solar heating systems. Energy sources compatible with a computerized installation include solar, wind, gas, electric, oil, wood and coal.

Some homes with sophisticated computer terminals may need an entire room or a special area of a family room to accommodate activities such as computer games, academic instruction, receipt of community or financial information, or picture telephoning.

Finally, the old home as well as the new home could be a candidate for computer systems. But retrofitting could bring particular problems. Sensors would have to be located as close as possible to existing wiring. Room radiators or ducts might have to be isolated from the entire house system and separately heated or cooled with instant water heaters, electric coils, or small air conditioners.

The following two sections focus specifically upon the design concerns of typical systems in the automated home: the ventilation system and the security system.

Humidity, Filtration, and Circulation Systems

Not all of these functions would pose a separate concern in the air system of the computerized house. Some could be used in conjunction with other outputs. For instance, outside air could be circulated to an oil furnace in order not to pollute a limited supply of air in a tightly constructed house. Also,

due to the tightness of fully insulated houses, humidity could become a problem. When it comes to decisions about humidity and circulation, a computer could select the best and least expensive means to maintain comfort. When it senses excess humidity, for example, it might compare the temperature of the outside air with that of the inside air and decide whether it would be less expensive to introduce cold air from the outdoors or to turn on the dehumidifier. When a person feels uncomfortable, often his natural instinct is to turn on the heater or air conditioner. But, a computer could decide if the same effect could be best achieved by humidifying, dehumidifying, filtering or circulating the air.

Typical outputs in this system would include: fans, humidifiers, dehumidifiers, electrostatic and passive filters and adjustments to windows.

The Security System Computers are already playing an important role in safety and security systems. These installations are expected to become even more popular with improved technology, including the introduction of central computers and the transmission of signals over existing house wiring, which may lower costs. Security capabilities would include sensing intruders and activating devices to prevent unwanted entry. Also, features such as the identification of approaching persons or vehicles and the taking of appropriate actions (such as opening a gate, sounding an alarm, or calling for help) could enhance the value of the system.

With regard to safety, many accidents in the home could probably be avoided or mitigated by proper detection and reaction. Although a fire warning system might be the most obvious application, others would include warning systems for fumes (especially in industrial applications), for electrical circuit problems, and for personal injury (so that a person who has fallen might summon help via a voice sensor).

Typical outputs would include: telephones, alarms, locks, sprinklers, lights, TV cameras, doors and gates.

CHARACTERISTICS OF THE COMPUTER

To the novice, a discussion of the makeup of a computer could prove more than a little mysterious. Since vocabulary plays an important role in understanding the computer field, this section begins with some basic definitions of essential terms. It focuses on the three major components of a computer system: the computer itself, inputs and outputs.

The Computer

The computer can be defined as a device that will recognize the standard English symbols (A-Z, 0-9, +, *, =, etc.), and it will:

a. Accept, store and act upon inputs formulated as instructions

b. Store data

c. Perform arithmetic

d. Compare data

e. Make internal decisions based upon comparisons of data that can affect outputs

f. Generate outputs

Computer Inputs

Because computers are made up of electronic components, the information they work with must also be in electronic form. Therefore, all inputs to the computer must be in the form of electrical signals. The internal code of the machine need not be explained in detail here since it is not especially pertinent to the discussion. However, some simple examples of how symbols, numerals and alphabetic characters can be translated into a language the computer can read might prove informative.

A computer operates on the "on" and "off" status that electric current has. Binary numbers best reflect this status, and are used in specific patterns to represent various symbols:

Symbol	Internal Code
A	0010000
4	0000100
*	0111011

Electrically, a "1" might be a +1 volt level, while a "0" could be a -1 volt level.

Input Devices

There are two general classes of inputs: manual and automatic. Manual inputs are those which would be entered by direct human control. The input mechanism could be a keyboard, light pen, card, scanner, or voice. Automatic inputs would originate from various sensors in the house. Temperature, humidity, smoke or burglar detectors, for example, could monitor for alarm conditions and warn the appropriate authorities when they were present.

All of these automatic devices would generate outputs in the format of established digital symbols. A thermometer, for example, would transmit "68.5", but, again, the computer would see "1000110 00010000 1000101."

Input Sensors

A sensor, for our purposes, is a mechanical and/or electrical device that receives and responds to a signal or stimulus. Present-day examples would include: a photoelectric cell connected to a counter to record the number of people entering a building; a smoke detector that triggers a bell or buzzer when smoke is sensed; and a simple magnetic switch attached to a window that sets off an alarm when the window is opened. Each sensor module would have a unique digital "address" and would not transmit information until the computer called for that particular module. For example:

Module Address	Function
23	Temperature in Room 2
44	Outside Temperature
68	Temperature in Room 6

As input values were transferred to a central processor, decisions would be made which would then affect output devices.

Sensor Types and Operation

In terms of home applications, input sensors can be divided into two classes: proportional sensors and positive decision sensors. Proportional sensors produce a digital output proportional to the quantity being measured. While these sensors may continuously measure the desired quantity, they will only transfer information when interrogated by the computer. Typical inputs would be temperature and humidity. Positive decision sensors, on the other hand, are characterized by simple "yes-no" outputs. Typical inputs would be smoke/fire, intrusion, a switch, or the energizing of a machine.

Input Modules

In the interest of simplicity, input modules could be combined to form "packages." A room module might, for example, control temperature, humidity, lighting, and burglary and smoke detection. One outdoor module might monitor temperature and humidity; another, wind direction and velocity; and a third. sun angle and ambient light.

It would be convenient if the input modules fit into a standard electrical box with the location of each box determined by the layout of the house.

Output Devices

Based upon internal instructions and measured data, the computer could energize one or more output devices such as heaters, heat pumps, furnaces, circulation fans, windows, roof vents, light alarms, valves, pumps, and display printouts.

Output Modules

Because the simplest and most easily controlled energy source in the home is electrical power, it would be convenient to have a "standard" output module that would fit into a conventional electrical box. When selected, the module would energize a socket on the box or wiring tied internally to the box.

Each module would contain a decoding matrix and relay and would respond only to a command from the computer that contained its specific address. For example:

Address	Action
23	Energize heater in Room 3
16	Turn on outside lights

Transmission of Input and Output Signals

The simplest method of signalling inputs would have the digital data impressed on an F.M. radio frequency carrier and routed over existing power lines to the computer. This F.M. transmission is virtually immune to noise and interference and no extra wiring would be needed.

INSTALLATION

Three aspects of installation would dominate the construction area: sensors, the computer itself, and outputs. Although much of the work might fall under the electrical trades' responsibility, other trades would participate, and the interface between trades would require close coordination. For instance, a pre-manufactured window, installed by carpenters, might have electrical circuits which must be connected to the house wiring for operation of window blinds or opening devices.

The sensors would probably be placed in a box similar to a receptacle box. During the electrical rough out, sensor boxes would be installed and connected by wire to the nearest receptacle outlet box. Exact location of these sensor boxes

would appear on blue prints. Some output transition boxes could be required, such as a box to hold a timer or switch, etc. Output boxes would be placed during rough in. Connections between outputs might require wiring within walls. Some outputs, however, could receive external wiring connected to house receptacles by a simple plug.

Finishing would consist of inserting any sensor or output modules in their respective boxes and connecting the prewiring. Also, connections to outputs such as furnaces, fans, windows, central computers, would be made at this time.

PRACTICAL IMPLICATIONS FOR LIVING IN THE HOME OF THE FUTURE

Automated homes of the future would probably contain TV monitors, cameras and microphones in nearly every room to allow visual and audio contact with the computer for security as well as for computer control. Since voiceprints are as unique as fingerprints, microphones could be used to trigger an alarm for any but authorized voices. (See Appendix for the section on voice input.)

Since the computer would be connected to the phone system, the home could be controlled from a distance. The homeowner could call the computer and direct it to close the windows or turn on the roast.

The advanced state of communications would very likely result in many people working at home. This could imply significant changes in lifestyle, as the 24-hour day would not necessarily contain an 8-hour time block for work. As more and more time would be spent at home, more effort and dollars would be spent toward making it into a "man's castle."

SELECTING SYSTEM COMPONENTS

The key to successful component selection is a careful assessment of the activities to be performed by the computer system. Three broad categories of home computer use have been identified: home facilities management (temperature,

lighting, security, etc.), local information processing (record album data base, checkbook balancing, games and entertainment, etc.), and community information processing (national buying services, news and stock market information, etc.). Careful study of the specific operations to be performed will determine the type of hardware and software needed.

Once the types of components needed have been identified, several additional factors must be considered:

1. What happens if a component fails? Will failure of a component cause failure of the entire system? Would system failure cause serious problems in the home?
2. Can the role of the system be performed manually, if necessary? Would this be desirable under some circumstances? Can the automatic features of the system be overridden? Is this desirable or necessary?
3. Is maintenance service readily available for the components selected? Can the system diagnose its own problems, allowing for quick, easy component replacement by the homeowner himself?
4. Will the operating software automatically compensate for malfunctioning components until they can be repaired or replaced? Do any components require special environmental conditions in order to operate properly? Is the size of the component or its location in the home significant?
5. Will the hardware and the software be able to resume operation automatically?
6. Will any components electrically interface with other devices in the home? Will data signals in transmission lines be affected by "fluctuations in voltage"? Will radio or TV signals be disrupted by electromagnetic radiation from any components?

Table 1 shows some typical home applications and some of the equipment needed to implement them. The functions to be performed will determine the software package used, but additional considerations might include its ease of use, its ability to recover from power outages, and the ease with which it could be customized as required.

Wherever feasible, multiple components of a given type should be incorporated in the system to enhance reliability by redundancy. Should a thermometer in one room become inoperable, for example, the readings from one in a nearby room might be used by the system to compensate until the inoperable one is repaired. The system should also be able to detect when a component is out of adjustment or on the verge of failure by recognizing abnormal conditions. If the furnace runs too long, for example, this might be an indication that a sensor is no longer working properly and that the homeowner should take corrective action.

The computers of the future may be special function computers. For instance, one computer might control burglary prevention and another heating and cooling with both tied into a general computer.

Two points about the following table should be amplified:

1. Each application could be performed by its own individual computer or all applications could be done on a single computer. Most likely, there would be some combination of computers performing various functions.
2. When a single computer is doing several applications, the amount of main memory needed would be that of the application requiring the most. If several applications are running simultaneously, there might be a need for the sum of their memory requirements, i.e. the memory requirement would be expanded.

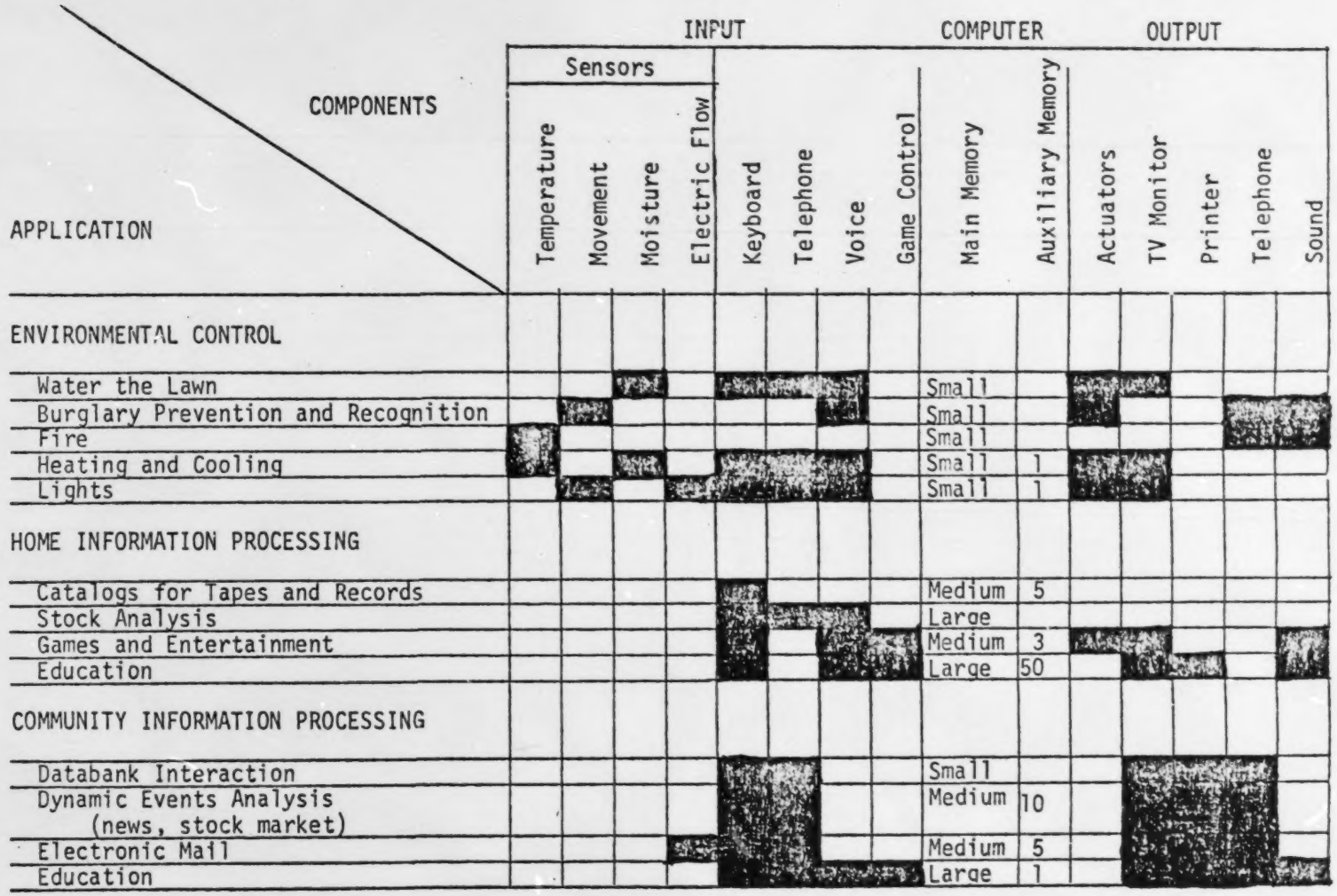


TABLE 1 -- TYPICAL HOME APPLICATIONS AND EQUIPMENT NEEDED

CHAPTER TWO

SPECIFIC MATERIALS FOR TEACHERS OF ELECTRICITY AND HEATING AND AIR CONDITIONING

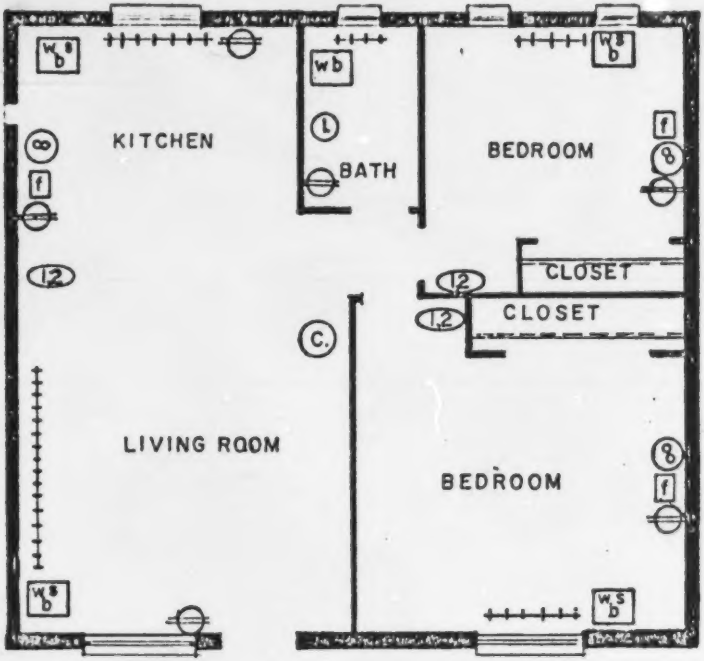
The trades which will be most affected by the addition of the computer in the home appear to be the electrical and heating and air conditioning trades. The following materials are designed as a guide for teachers in these trades, to help them develop lesson plans which would introduce students to the concept of computerized homes and buildings.

The chapter is divided into four sections. The first reviews installation procedures for plans which illustrate the placement of sensors and it discusses the function of the computer in two types of heating/cooling systems. The second section deals with hardware considerations for input and output devices. A detailed discussion of sensors comprises section three. The fourth section contains sample problem worksheets for students in electricity and in heating and air conditioning classes.

INSTALLATION PROCEDURES

When starting a job on new construction, the computer/electrical installer should have in his possession a set of complete computer wiring. Other materials such as ordinary electrical wiring and mechanical equipment may also be indicated on the prints. On some smaller installations, particularly retrofit jobs, prints may not be available, and the installer could be asked to create a plan.

The two exhibit prints on the following pages demonstrate possible uses of computer concepts. One print depicts a house with electric baseboard heating (no air conditioning), and the other shows a home with forced-air central heating and air conditioning. The air system includes a central dehumidifier.



NOTES:

1. WHEN AN OUTPUT CONTROL OPERATES MORE THAN ONE DEVICE, CONNECT IN PARALLEL SO COMPUTER CAN DECIDE WHICH ARE ON AND WHICH ARE OFF.

2. CONNECT INPUT AND OUTPUT BOXES TO NEAREST RECEPTACLE

3. TIME IS AN INPUT FACTOR WHICH THE COMPUTE WILL KEEP TRACT OF.

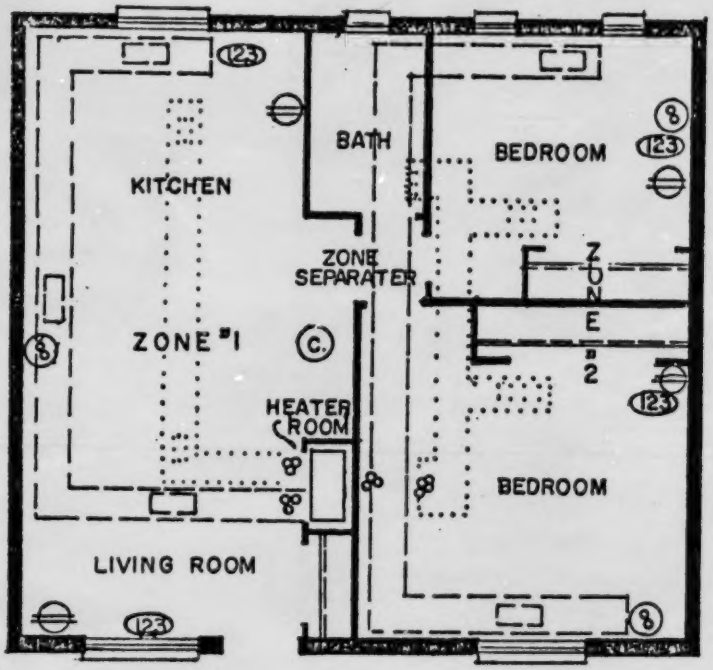
4. ALL INPUT AND OUTPUT DEVICES PLUS COMPUTER ARE CONNECTED TO HOT HOUSE WIRING

++++ ELEC. BASE
WINDOW
RECEPTACLE
F FAN
C COMPUTER

ON-OFF OUTPUT CONTROL
w WINDOW
s SHADE
b BASEBOARD HEATER
f CIELING FAN
T THERMOSTAT

INPUT SENSOR
1. ROOM TEMPERATURE
2. OUTSIDE LIGHT

ELECTRIC BASEBOARD HEATING SYSTEM



NOTES:

1. COMPUTER TO DECIDE IF FAN GOES ON OR OFF, AND WHICH WAY TO MOVE THE AIR.
2. ZONES TO BE SEPARATED WITH AIR TIGHT AUTOMATIC CLOSING DOORS
3. CONTROL PLENUM HAS MECHANICAL AIR COOLING
4. DEHUMIDIFIER TO BE PLACED IN MIXING PLENUM

- DUCT IN CIELING
- COMP. CONTROLLED LOUVER
- FLOOR DUCT
- LOUVER
- MIXING PLENUM
- ON-OFF OUTPUT CONTROL
  - w.. WINDOW
  - l.. LOUVER
- OUTSIDE VENT FAN
- 2 WAY FAN
- RECEPTACLE
- INPUT SENOR
  1. ROOM TEMPERATURE
  2. OUTSIDE LIGHT
  3. HUMIDITY

AIR HEATING SYSTEM

The installer would arrive on the job for rough-in with his normal set of equipment plus the following:

--input sensor boxes, which would either look like or be identical to receptacle boxes.

--low-voltage wires to connect the sensor boxes. The number of wires in a cable would be determined by the number of sensors shown for each location. In most cases these sensor wires would simply be strung between the sensor box and the nearest receptacle box. In some cases, however, they may be run directly to the computer. The blueprint would specify which practice to follow.

--output connections to windows, fans, shades, heaters, air conditioners, etc. Some of these outputs will be equipped with ordinary plugs and will not require output boxes. They should be so noted on the plans. Most will be connected directly to the house wiring, and the wiring during the rough-in stage should be brought right up the output.

During the final stages of construction, the installer will return for final work. The internal wiring now will be covered by walls and windows will be in place. The installer will place and connect the electric baseboard, the central computer, and the fans to the outside. At this time, too, he will insert the sensor components and the input elements into their respective boxes. Connection proceeds just as with receptacles, using wire nuts. In the case of any low voltage wires going directly to the computer rather than to house wiring, normal connections to the computer and sensor would be made with low voltage wires already strung within the walls.

HVAC work in a computerized system is not significantly different from that done in conventional systems, as reflected in the air heating print exhibit. Similarities exist in the idea of zones, return and distribution

ducts, humidifiers, and mechanical cooling units. The differences include, in the computerized system, the addition of outside vent fans, two-way plenum fans, computer controls, and sensor connections.

STATE OF THE ART

The commercial availability of components generally lags behind the "state of the art" by eighteen months to two years. Historically, only high market demand has helped to narrow this time gap. In the case of input and output devices for home computer installations, there is a clear market gap, largely because of a lack of market demand. Until very recently, all of the available literature on home computers appeared in publications aimed at hobbyists. Like all "new" developments (radio, TV, CB, high fidelity) the application of computers to the home market has had to pass through this early development stage.

State of the Art

No requirements in any phase of home computer applications are beyond the existing technology in electronics or mechanics. Most of the necessary devices already exist at the industrial level. But here, precision standards are high and financial returns are great; and the elevated price of computer components reflects this. Before home systems can become commonplace, a set of lower performance, lower priced components must appear on the scene. These devices will appear as soon as the market is right.

Hard Wiring. It would appear, at present, that the cost of hard wiring can compete with the more exotic forms of data transmission, such as power line radio transmissions. The expanded use of hard wiring techniques should result in additional learning modules in vocational training in the appropriate trades. Skills acquired in this area will closely resemble those in what is known today as "Intercom Wiring" (multiple conductor, small diameter, unshielded cables). Any interference problems could be minimized by specifying low impedance devices.

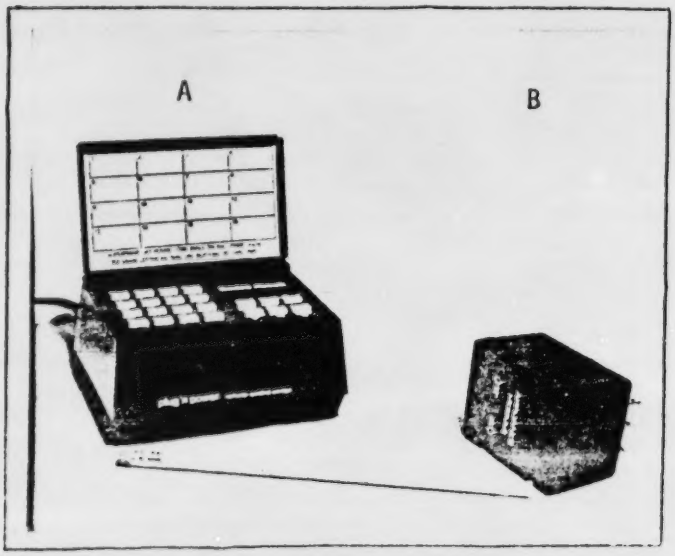
Wireless Systems. Since hard wiring is only competitive economically for new structures, wireless systems will predominate in the retrofit market, which will be the largest for obvious reasons. The wireless technique has the additional advantage of total flexibility since a system employing it can be reconfigured at will. Vocational training should include the skills required for this new technology.

"Off the Shelf" Hardware

A survey of available components reveals a narrow market. While a multiple of small suppliers exists, predictions are that most of them will not have the capital holding power to stay in the market. Some of the larger corporations are just beginning to respond to the market.

Output Devices. Since output decisions from a computer are generally discrete in nature, output devices are relatively simple to fabricate. The available units reflect this, and sufficient mechanisms are available to supply present needs. (See Figure 1.)

Figure 1



A - Control Unit
B - Output Module

Input Devices. Providing input to a computer proves to be a more difficult task than harnessing output. For our purposes, all input devices, or "sensors," perform the same basic function--measurement of environmental parameter (e.g. temperature, humidity, light intensity). The sensor is a self-contained unit that performs continuous measurement, independent of the computer, and produces constant output usually in the form of an electric current. This output is proportional to the stimulus affecting the sensor; i.e., as the stimulus changes, the intensity of the output current changes. Most sensors, then, provide output in analog form. Because computers want data in a discrete, or digital, form, the sensors' analog data must be translated by an analog-to-digital (A/D) converter, readily available today.

Conclusions

Installation of a home computer would require some interface hardware. Temperature sensing could be handled by an analog to digital converter. No electronic device now exists to digitally transmit humidity data, but a conventional hygrometer could be utilized as an adjustable contact device (similar to a standard thermostat) with the contacts signalling the computer. Most other inputs could be handled by switch information.

The cost of the very first home computer systems would be very high (usual for any prototype machine); the actual cost of systems once production of them begins in earnest would certainly be less.

Several small computer companies are entering the field of facility management. There are companies who will install complete facility management systems. The cost, however, is still relatively expensive.

SENSORS

For our purposes, a sensor has been defined as a mechanical and/or electrical device that receives and responds to a signal or stimulus. Photo-electric cells which record the number of people entering a building, smoke detectors that activate a bell or buzzer when smoke is sensed, and magnetic switches that set off alarms when windows are disturbed are all examples of sensors.

Sensor Concepts

The sensor is only one component of a given system, and it does not perform the actual counting of signalling in the examples above. When stimulated, a sensor responds by producing a single electric current which is sent to a second component of the system, usually via a wire. This second component analyzes the incoming information (electrical current) and decides to act, a third component of the system performs the action (an alarm is turned on, a counter is ticked, etc.). The configuration of the three basic components of a conventional sensor/actuator environment -- the sensor, the decision maker, and the device to be activated -- is shown in Figure 2 on the following page.

Basic Configuration

Internal and external information processing and facility management have been identified as the proposed major tasks of the home computer. The first two of these would require only a computer and no sensors. However, facility management would be implemented in an environment like the one shown in Figure 3; that is, one which would include sensors. Here, the computer becomes the single, central decision maker. Since the computer

permits easy manipulation of criteria for positive decisions, its flexibility makes it a natural for the job. A typical configuration for a network of sensors that might monitor a home or other building is shown in Figure 3 on the following page.

Figure 2

Configuration of Three Basic Components
of Conventional Sensor/Actuator Environment

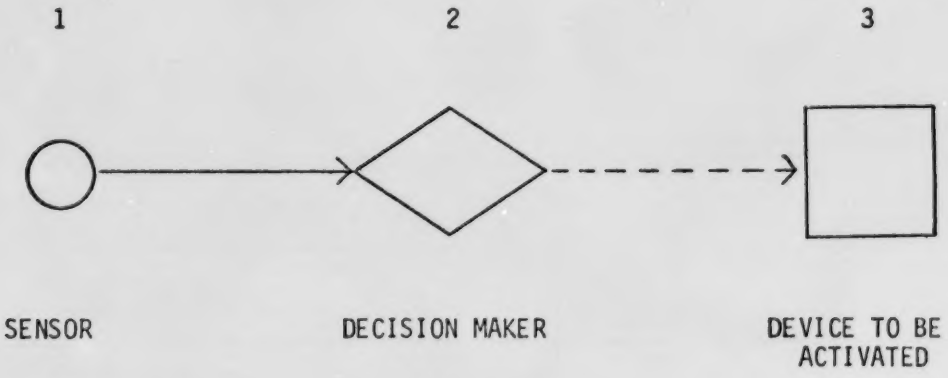
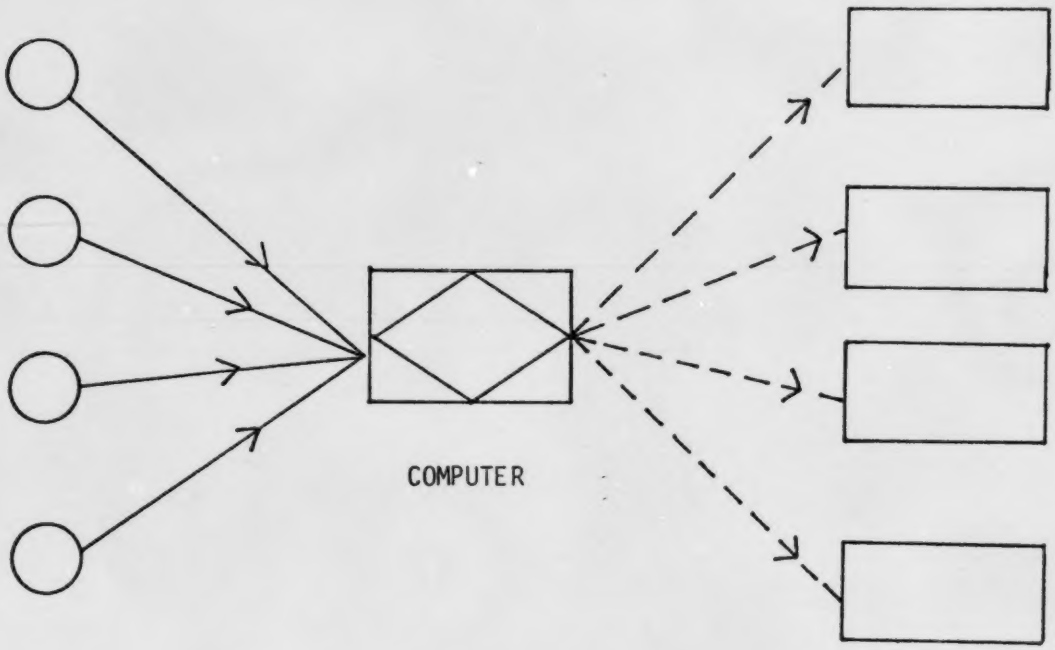


Figure 2 -- The line connecting components 1 and 2 is solid because the decision maker constantly monitors the output of the sensor. However, component 3 is not activated after each decision, as suggested by the dashed line.

Figure 3

Configuration of Three Basic Components of Sensor/Actuator Environment with Computer as Decision-Maker



Analog vs. Digital

A brief discussion of how sensors are installed may be helpful. Our definition of a sensor says that it receives and responds to a signal such as a radio wave or normal house current, or to a stimulus such as temperature, pollen, smoke, etc. In reaction to a signal or stimulus, almost all sensors produce an analog current; very few produce a digital current. This distinction is important because a computer wants information in digital form. Essentially, the difference between analog and digital current is the difference between a constant versus a pulsing electrical flow. A sensor that produces digital data emits electrical pulses that can be counted by the computer. An

obvious disadvantage of all sensors is that there is a limit to the accuracy of their measurements. However, for our purposes, that limitation need not be a consideration.

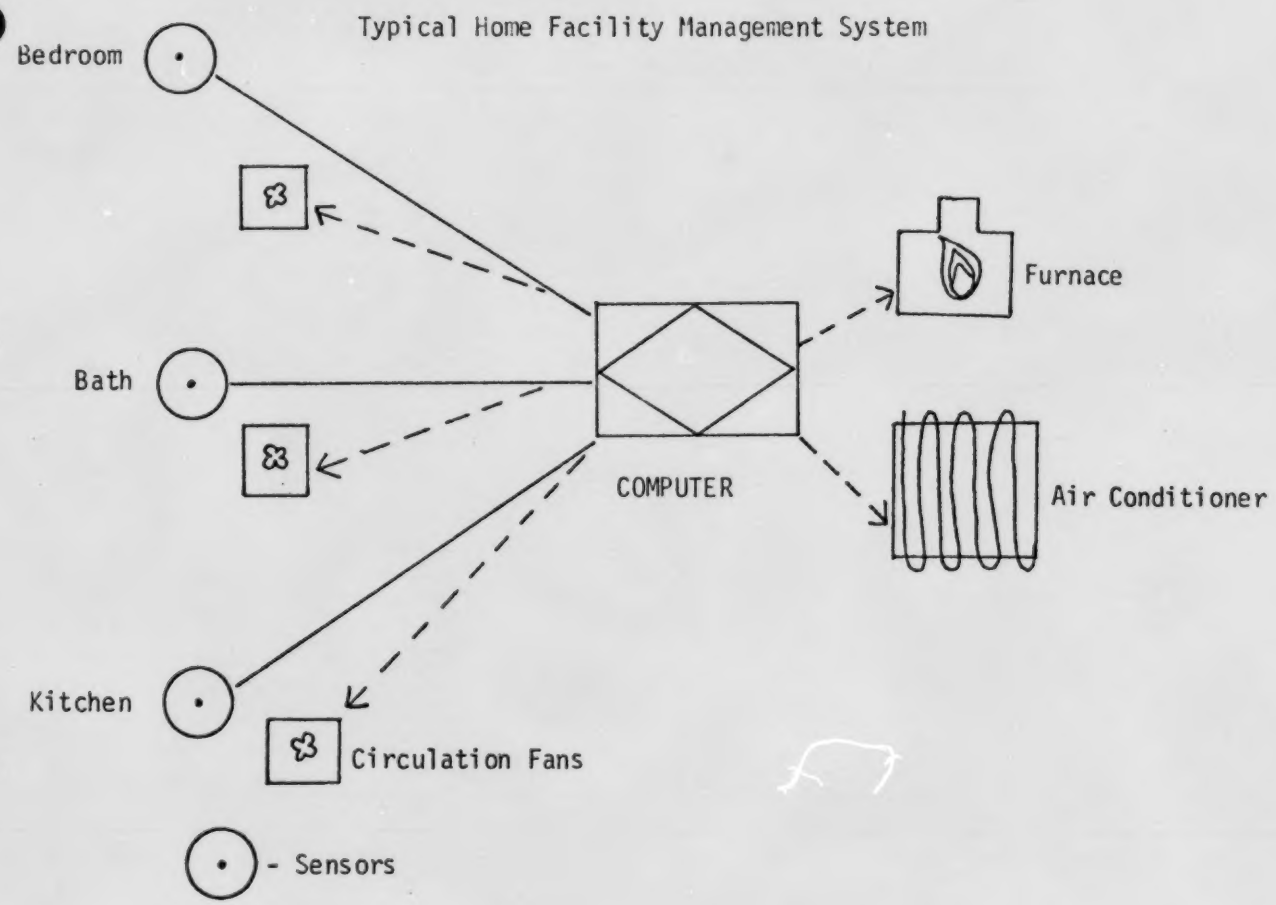
Because most sensors provide analog information and the computer wants digital data, a conversion must be made before the information reaches the computer. Some computers will make this conversion themselves, but often, due to the number of necessary conversions, it is best to do them outside the computer. This task is accomplished by an electronic device called an analog-to-digital (AD) converter. The AD converter could be placed on the front end of the computer with all sensors simply plugging into the computer. Or, each sensor could be set individually to convert and transmit digital information.

Sensors at Work

Let us look at a real life example of a sensor/actuator environment. Energy conservation through facility management is already a reality in some buildings and is likely to become an integral part of all structures in the future. A typical configuration for a home facility management system is shown in Figure 4 on the following page. In such a system, each room would have a thermal sensor connected to the computer. Periodically, the computer would check the temperature of each room to see if a given temperature range (e.g., 65°F to 75°F) had been violated. If, for example, a bedroom sensor indicated that the temperature had dropped to 63°F, the computer would attempt to raise the temperature. First, air from warmer rooms would be circulated into the bedroom via fans in the duct system. If this were not sufficient to raise the temperature, the furnace would be turned on and warm air blown only into the cold room (dampers to the other rooms would be closed by the computer). A similar process, possibly involving an air conditioner, would be initiated if the temperature of a room were to exceed 75°F. In such a system, the computer would decide if action were necessary, and would activate an output device if necessary (circulation fans, furnace, and air conditioner).

Figure 4

Typical Home Facility Management System



Review of Sensor Types and Operation

When examined in terms of home applications, input sensors can be divided into two classes: proportional sensors that produce a digital output proportional to the quantity being measured (temperature, humidity), and positive decision sensors that create a distinct "yes-no" output (smoke, rain, intruder).

Proportional Sensors. In this discussion all sensors produce digital outputs of required accuracy. While all sensors may continuously measure the desired quantity, they will only transfer that information when interrogated by the computer. Each sensor has a unique two-digit address. This system permits operation of a minimum of 100 sensors, which should prove more than adequate for the proposed home applications.

(a) Temperature Sensors. Most temperature detectors are resistive in nature and are of three types: simple thermally-sensitive resistors such as thermistors; solid state junctions that exhibit linear voltage-current outputs as a function of temperature; and integrated packages containing combinations of these two types.

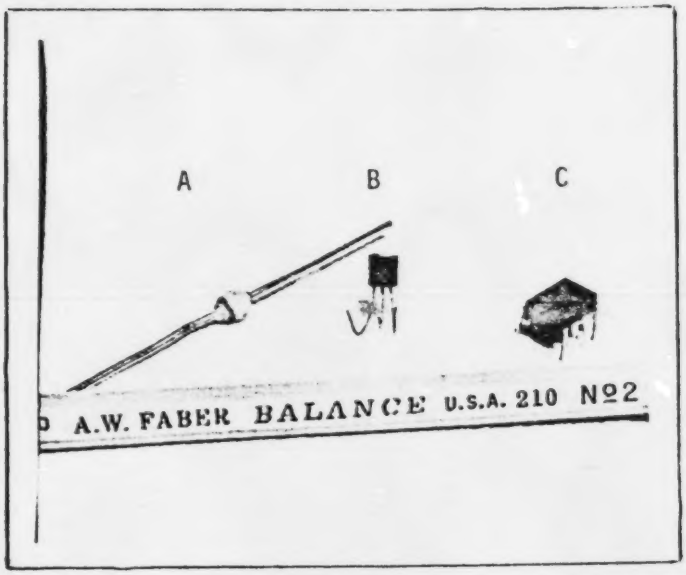
Thermistor Sensors. To achieve linear performance these are generally packaged as a matched pair in a single unit (Sylvania 4400 series). The output is then amplified and converted to digital format. Physically, they are compact (.2" x .1"); use of an integrated amplifier-converter adds a new unit of less than one cubic inch. They are functional over a range of -55°C to 100°C, and are adequate for home applications. (See Figure 5A.)

Solid State Junction Devices. These packages employ a silicon transistor (2NZZ22) to sense temperature. A picture is given in Figure 5B. This transistor type exhibits a junction voltage that is a linear function of temperature. It operates from -50°C to 100°C and is less expensive than thermistors.

Integrated Circuit Package. This unit contains an internal sensor and amplifier packaged in a standard I.C. assembly (LM3911) which is larger than (1) and (2) above, but totally suitable for the unit proposed. It will withstand great abuse and operates from ±25°C to 85°C. (See Figure 5C.)

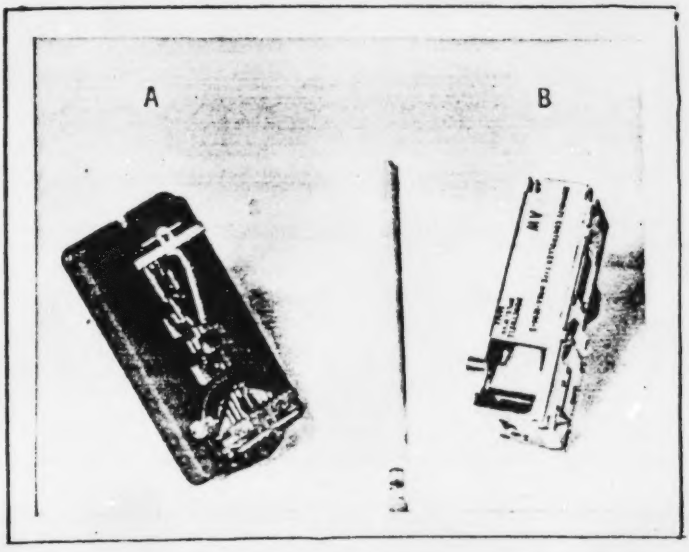
(b) Humidity Sensors. Sensing humidity is difficult. The size and cost of a humidity system would be directly related to the precision required. Fortunately, the tolerance of -15% relative

Figure 5



A - Thermistor
B - Reverse Junction Silicon XSTR
C - I.C. Package

Figure 6



A - Hair Humidity Sensor
B - Nylon Humidity Sensor

humidity in home applications permits some savings. A synthetic thermoplastic detector now available would perform adequately in a home setting. Figure 6 gives a picture of a hair and nylon humidity sensor. A separate digital converter would be used.

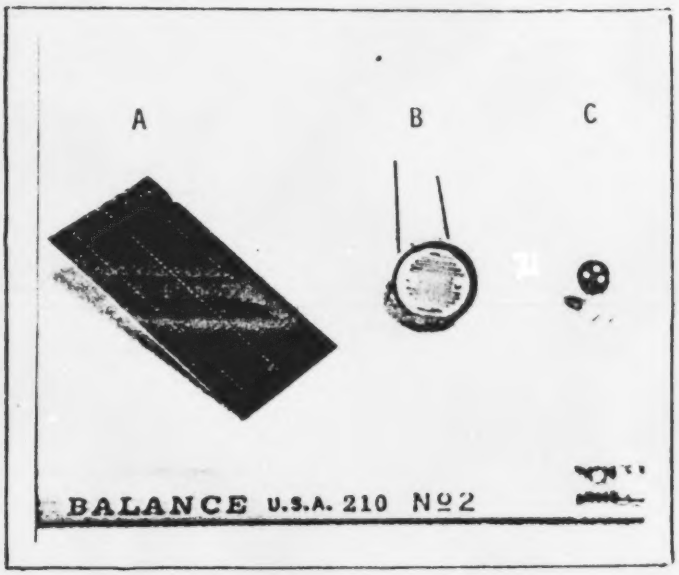
(c) Light Sensors. A wide variety of light sensors are available and offer an array of cost/performance trade-offs. Photovoltaic sensors offer direct output from light (Sylvania 220C) but are expensive (see Figure 7A). Figure 7B presents a less expensive photo-resistive sensor which will also perform well (Sylvania-CL5M7). Photo-transistors which offer internal amplification (Sylvania-CLT2100) may also be employed (see Figure 7C). So, the problem of light measurement could be handled easily.

(d) Optical Motion Detectors. These devices are used in conjunction with assorted circuit devices to provide an intrusion detection circuit. A typical unit (Sprague-ULN2232H) is designed to sense slow changes in light level and to ignore flashes and other rapid inputs (see Figure 8). The device is usually surrounded by circuits to create the required delays for arming and disarming, but the computer could provide these services. This unit could perform task (e) below as well as motion sensing.

(e) Outside Air Measurement. Outside air temperature and humidity could be measured by the same techniques outlined in (a) and (b) above. The physical packaging would have to be modified to meet outdoor environmental conditions.

(f) Wind Direction and Velocity. Wind velocity could be measured by a suitable anemometer driving a permanent magnet generator. This configuration would deliver an electrical output proportional to velocity, which could then be converted to digital output and

Figure 7



A - Photo Voltaic
B - Photo Resistive
C - Photo Transistor

Figure 8

Monitor Detector

routed to the computer and interpreted in M.P.H. Wind direction could be sensed by an eight-point-sensing aerodynamic vane, and then converted and routed to the computer. This device is available with optical, infrared, magnet and proximity sensing, all requiring no mechanical contacts.

(g) Domestic Hot Water and Solar Sensing. The same temperature sensing elements described in (a) could perform this task, but high temperature ratings would have to be used in selecting the sensors.

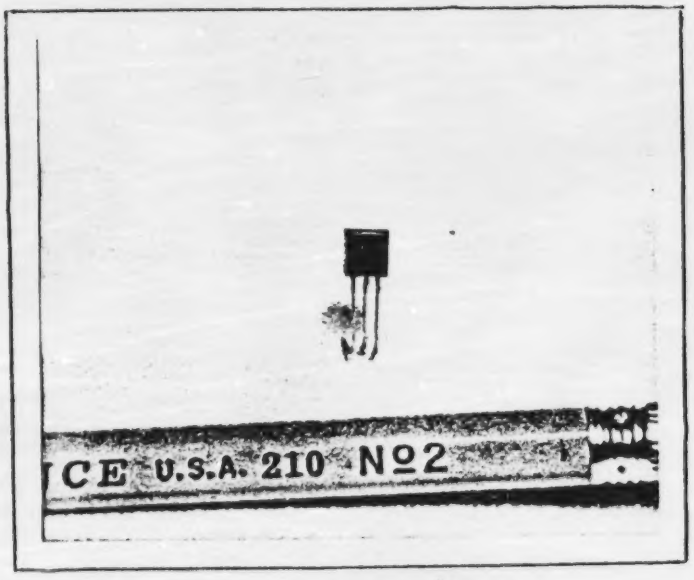
(h) Safety and Instrusion Devices. Switch closes (combination locks, switches, keyboards) readily generate electrical signals, since the process becomes simply a matter of converting mechanical motion to current/voltage. Excellent products with impressive reliability records are available in applications where switches can be tolerated. In voice actuated units, microphones are backed by intelligent analysis of inputs by the computer. However, the state of the art in voice recognition by computer is primitive. With improved techniques such a system should prove feasible.

(i) Energy Device Monitors. These would measure electrical power consumption, the running time (hours/minutes) of a machine, etc. Since utilities now transmit from digital wattmeters over power lines for billing purposes, the technology already exists for this application. Since most machines irvolve mechanical motion their control would be similar to that described in (h).

Positive Decision Sensors

These devices, characterized by "yes-no" outputs, generate a voltage for "yes" and none for "no." Typical inputs would be: smoke/fire, intrusion, throwing a switch, or starting a machine. One positive decision device, the precipitation detector, deserves special attention since it involves operation not yet discussed.

Figure 9



Hall Effect Electronic Switch

Since only the presence of precipitation and not its quantity must be determined, the task is relatively easy. There are three popular detection units: optical, resistive and sonic. Optical units sense a change in light transmission caused by water or snow and are subject to contamination over time. Resistive units employ a plate and measure current leakage. They, too, can become coated. The sonic system is essentially a sealed microphone sensing the impact of raindrops, hail or snow. It performs marginally under conditions of light snow and no wind, but this is not a critical condition for structure protection.

WORKSHEETS

Since the normal teaching procedure in vocational classrooms is to provide "hands-on" experience, sample application problems which do just that are provided here. They are also meant to encourage teachers, who alone best know their students' abilities, to provide additional cases of their own relating to the construction of a computerized home.

Work Sheet #1

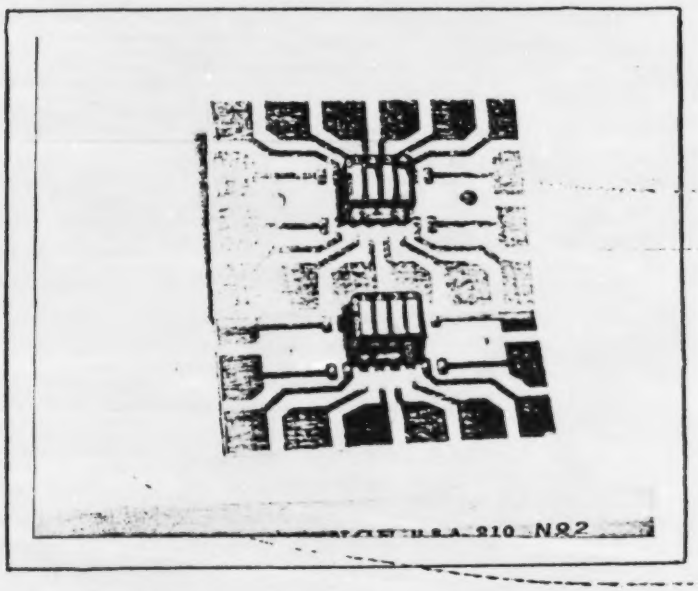
SUBJECT: Input-Output Sensors

REQUIRED EQUIPMENT: Sensor Panel

OBJECTIVE: To set addresses for sensors as specified by house wiring specification sheet

DISCUSSION: Figure 10 is a sensor panel. The upper switch is the input address and the lower is the output address. The four switches use the following code:

Figure 10



To achieve a desired address, numbers are added together.

Example:

Depressing the two outside switches would produce:

(8 + 1) = "9" address

PROBLEMS:

1. Input address = 7
   Output address = 12

2. Input address = 13
   Output address = 3

3. Input address = 10
   Output not used

4. Input address = 11
   Output address = 16

QUESTIONS:

1. In Problem 3 which output switch settings should be used?

2. In Problem 4 what can be done for the proper output address setting?

Work Sheet #2

SUBJECT: Computer Sensor Wiring

REQUIRED EQUIPMENT: Two terminal boxes
Eight wire cables (not color coded)
Market tape
Continuity tester (buzzer/meter)

OBJECTIVE: To wire eight conductors in one-to-one correspondence

DISCUSSION: The left hand box has eight terminals and the right has a similar terminal block. The first box should have the top wire matched to the top wire in the second box, the second wire to the second, etc., and the bottom wires should be matched.

PROCEDURE: Label the right hand wires 1 through 8 using the marking tape. Mount the wires in order on the terminal box.

Identify the wires in the second box using the tester. Label each wire and mount on terminal block. When wiring is complete, check all eight lines.

PROBLEMS:

1. Assume second box is located in another room. How can you identify the wires and connect them? (Wires can be shorted together by twisting the connections.)

2. A sensor box cable is defective. (One or more wires possibly open or shorted). Power is off. (Check to be sure.) How would you test the eight wires to determine the trouble?

THE TOTAL COMFORT SYSTEM

WORKSHEET #1

SUBJECT: Troubleshooting (Ducted System)

EQUIPMENT REQUIRED: Meters and gages to measure voltage, amperage, air flow, temperature and humidity. A room sensor test module and specification sheet.

OBJECTIVE: To correctly identify the problem and take action necessary to return system to normal operation.

PROCEDURE:

1. Analyze/verify customer complaint.
2. Insert test module and "zero" computer. If normal replace test module with original.
3. Place system on manual control. As required measure system voltage and amperage at main power supply. Measure air flow, temperature and humidity in problem area.
4. Refer to system specification sheet to determine abnormal conditions.
5. Take appropriate corrective action.
6. Return system to automatic control.

RECORD THE FOLLOWING INFORMATION:

A. Voltage _____ Amperage _____

B. Zone Temperature _____

C. Zone Relative Humidity _____

D. CFM _____ Filters _____

E. Fan Motor _____

Troubleshooting (continued)

Worksheet #1

F. Fan Discharge Temperature _____

G. Cooling/Heating System (Normal?) _____

H. Refer to Check Sheet as Required.

THE TOTAL COMFORT SYSTEM

WORKSHEET #2

SUBJECT: Troubleshooting (Non-Ducted System)

EQUIPMENT REQUIRED: Meters and gages to measure voltage, amperage, and temperature. A room sensor test module and specification sheet.

OBJECTIVE: To correctly identify the problem and take action necessary to return system to normal operation.

PROCEDURE:

1. Analyze/verify customer complaint.
2. Insert test module and "zero" computer. If normal, replace test module with original.
3. Place system on manual control. Measure voltage and amperage at main power supply. Measure zone temperature in problem area.
4. Refer to system specification sheet to determine abnormal conditions.
5. Take appropriate correction action.
6. Return system to automatic control.

RECORD THE FOLLOWING INFORMATION:

A. Voltage _____ Amperage _____

B. Zone Temperature _____

C. Heating System Normal? _____

D. Refer to Check Sheet.

CHECK SHEET - COOLING /HEATING

Homeowner's Name _____

Address _____

Date _____ Man _____ Time In _____ Time Out _____

Furnace Make & Model _____

Comments by Homeowner _____

_____

AT THERMOSTAT

- ☐ Record thermostat set-point. _____
- ☐ Check thermostat for dust or dirt and level.
- ☐ Turn thermostat to "lowest" cooling setting.

AT FURNACE

- ☐ Check supply voltage and record Time _____ Voltage _____
- ☐ Clean or change filters.
- ☐ Clean out blower wheel and blower compartment.

BELT-DRIVE BLOWERS

- ☐ Check all wiring in blower compartment for loose connections or bad insulation.
- ☐ Remove blower belt and check for wear.
- ☐ Check blower belt and motor bearings.
- ☐ Check pulley and drive alignment.
- ☐ Check pulley and drive set-screws for tightness.
- ☐ Check motor bracket for tightness.
- ☐ Check blower for free operation.
- ☐ Lubricate blower and motor bearings.
- ☐ Put belt back on blower and drive pulleys and check belt tension slippage.

DIRECT-DRIVE BLOWERS

- ☐ Check all wiring in blower cabinet for loose connections and bad insulation.
- ☐ Check motor bearings.
- ☐ Check for free blower operation.
- ☐ Check blower set-screws for tightness.
- ☐ Lubricate motor bearings.

EVAPORATOR COIL

- ☐ Check and clean cooling coil.
- ☐ Check and clean condensate drain.
- ☐ Check static pressure.
- ☐ Check temperature difference over coil.
- ☐ Check for proper voltage at transformer and evaporator blower.

CONDENSING UNIT

- ☐ Check and clean condenser coil.
- ☐ Oil condenser fan motor.
- ☐ Check and record supply voltage.
- ☐ Check all wiring for loose connections.
- ☐ Check all wiring for damaged insulation.
- ☐ Gauge refrigeration system and check operating pressures.
- ☐ Check refrigerant charge.
- ☐ Check amperage draw on condenser fan motor. Nameplate _____ Actual _____
- ☐ Check amperage draw on compressor. Nameplate _____ Actual _____
- ☐ Visually inspect connecting tubing and coils
- ☐ for evidence of oil leak.

Return thermostat to original set point.

If unit not running, refer to Service Handbook for cause of trouble.

BE SURE TO LEAVE ALL AREAS NEAT AND CLEAN!

APPENDICES

VOICE OPERATION

The idea of computers responding to the human voice and carrying out verbal commands has long been a theme in science fiction, from George Orwell's 1984 to movie hits such as "2001: A Space Odyssey" and "Star Wars." As has so often happened this century, science fiction is again moving toward scientific reality. But because voice-operated computer technology is very new and costs are high, there is currently little real life application.

For use in the home and small buildings, this technology can be divided into two areas: voice recognition and voice response. Voice recognition occurs when the computer "speaks" rather than to print out information on a terminal or video screen. Recognition is, by far, the more difficult capability.

Getting a computer to speak is a relatively straightforward process. First, a program is executed and the results are stored in the computer's memory. Then, rather than display the results in written form, the computer references a dictionary of recorded words and phrases to produce oral output via a conventional magnetic speaker. The dictionary need not record every word in the English language since some words contain other words (e.g.,"important"contains the word "import" and "example" contains the word "exam") and some words are combinations of other words (e.g., "sometime"). The more words a computer can speak and the greater its ability to form complex, grammatically correct sentences, the greater its cost. This is only one of two major ways computers speak. The other way is thru use of phonemes and is quite popular today.

To have a computer recognize a human voice and decipher a series of words is a more difficult task. The problems can be divided into two logical groups: recognizing the voice of the speaker and interpreting his words. There are several variables in recognizing a voice: should the computer recognize all voices or only certain ones; if the computer is to recognize only certain voices, what happens if one of those has a cold and his or her voice is different; what if two people speak at the same time and create an unrecognizable voice. Also, in designing a voice recognition system, a command vocabulary must be formulated: should the computer recognize a fixed vocabulary of key words (e.g., "computer," "open," "start") or a free format human vocabulary. Obviously, the free format system would be much more expensive than the fixed one.

Systems in answer to all of these questions have already been developed. At this time, however, their cost is prohibitive for large industries, as well as home or small business use. As their cost declines, voice recognition and voice response should have many uses in the home and in business:

-- Security. Entrance would be permitted only if the computer recognized the voice.

-- Verbal command entry. This would save time and would allow non-typists and handicapped individuals access to the computer.

-- Phone inquiry. One could call the computer from a remote location to ask questions about security status, business records, etc.

-- Supervision. The computer could "baby-sit" small children when adults were not present.

When such systems become financially feasible, the only peripheral equipment needed will be microphones and speakers.

Example of Computer Control of Facilities. To control building facilities the computer must have the individual specifications for the control variables entered by the owner or serviceman. A typical list might appear as:

Location	Day Temp.	Night Temp.	Humidity
Room 1	68°	60°	45°
Room 2	70°	66°	50°

The computer can store these data and compare them to the readings from the specified sensor in order to take appropriate actions. A brief explanation of the typical operational cycle for each input follows:

A. Temperature Control. This control module contains a sensitive device for translating temperature into a two-digit value. When the computer interrogates that particular module, the digital reading is transferred to the computer and is then compared to the specified temperature for that location. If the difference between the sensed temperature and the specification is significant, the computer transmits a command to the proper control module and either heat or cool air is supplied. When a subsequent "scan" reveals the temperature is satisfactory, a command issent to the control module to terminate heating or cooling. The computer, by scanning many input modules in sequence, can simultaneously perform as a thermostat for a multitude of sensors and provide independent temperature setting for each. The reference temperature can be changed automatically by changing the "Night/Day" profile stored in the computer or by manual intervention.

B. Manual Intervention. An option button on the module will refer the computer to Second Reference Temperature (stored in the memory). This new setting will remain in effect until the option button is reset. This permits departures from scheduled usage when needed.

C. Humidity Control. The sending sensor in this application transmits a single digit (4 = 40% R.H.) to the computer. The program will first examine other locations in the dwelling since a simple mixing of air from another room may satisfy the requirement. The outside temperature humidity will also be examined. If no satisfactory solution is evident, then the appropriate humidifier-dehumidifier equipment will be energized.

D. Outside Air Exchange. Depending upon the interior conditions, outside air ventilation may be instituted. Since a monitor of outside conditions is maintained, the transfer can be scheduled under optimum conditions. For instance, during cold seasons, the warmest part of the day would be selected for air exchange, and during the warm seasons, the coolest time would be chosen.

E. Room to Room Air Transport. In addition to air exchange needs for specific applications, a low level flow of air could be maintained at all times to promote efficiency and comfort. Single speed fans would suffice for all applications since the computer could create a "variable speed" fan by varying the duty cycle of each fan. A fan with a capacity of 100 C.F.M. operated for five minutes on - five minutes off (50% duty cycle) will deliver 50% or 50 C.F.M. A ten to one speed range could easily be obtained.

F. Wind Utilization. An external sensor could transfer readings on wind direction (1 digit) and wind velocity (1 digit). The digits from 1 to 8 could represent directional points on a compass, and each digit of velocity could be multiplied to represent 5 M.P.H. increments.

Conditions often exist when neither heating nor cooling of the home is required. Under these circumstances, the system would operate the outside vents and, if desired, open appropriate windows. Detection of precipitation would close all openings.

G. Domestic Hot Water. Consumption of domestic hot water for a social unit will generally follow a fixed pattern. Since holding losses account for almost half of the operating cost of a hot water system, the computer can anticipate the demand peaks and supply only sufficient energy to match the peaks. Since the heater will no doubt be electric with an integral heat pump booster, the savings should be considerable.

H. Solar Heat. A solar plant, like any engine, operates more efficiently as its temperature rises. Often these plants, whose technology is rather simple, continue to transfer heat after a desired temperature level has already been achieved. By monitoring collector temperature time behavior the computer can easily provide considerably higher performance than the existing fixed threshold devices currently in use.

I. Safety and Security. Optical motion detectors, previously described, will detect any sort of motion including that generated by fire and/or smoke. The use of a conventional smoke detector, in addition, should provide a highly reliable sensing/warning system.

The optical system can be programmed to detect an intruder and to recognize when an empty room no longer needs light.

J. Equipment Malfunctions. The installation of a digital running time meter (transmit to computer) coupled with the availability of outside measurements makes possible a continuous historical monitor for energy consumption per degree-days. (The computer could calculate the degree-days from the maximum-minimum temperatures.) Any radical change in this ratio would indicate a problem. A printout describing the problem could be executed. This would operate for both heating and cooling.

K. Failure Mode. In the event of a computer failure, a manual box would be available to allow general control of key variables, until repairs were made. Automatic alarms and/or switchover could be incorporated.

L. Payback. All of these operations would be economically feasible because of the payback savings produced by the devices. With the cost of energy rising and the cost of computers falling, it should not be difficult to fabricate a viable system.

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